Why NASA?

NPS/PCA/CSA/CCRS/NASA Workshop on Coordinating Approaches for Utilizing Remote Sensing-Earth Observation (RS/EO) Data to Monitor and Report Landscape Dynamics in and Around Protected Areas

Woody Turner

Science Mission Directorate

NASA Headquarters

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The Problem: Biodiversity Loss

- **Biodiversity appears to be declining rapidly**
  - **Estimates say at 100-1000x the "normal" background rate**
  - **Main Causes**
    - **Land Use Change**
    - **Invasive species (including pathogens)**
    - **Hunting/Fishing/Other extractive uses**
    - **Climate Change**
- **Our uncertainty of: total # of species < their distribution < their biology**

What can NASA do? Can remote sensing and ecological models improve our knowledge of where to use our limited resources for biodiversity conservation?

Protected Areas

- “Core” territories, i.e.: the center must hold!
- Eyes on North American PAs
- CSA/CCRS/PCA leading the way at national level
- NPS I&M Program a fresh start building on efforts of pioneers like Anita Davis (Thanks John!)
- Bruner et al.: tropical PAs effective
- DeFries et al.: buffers hit harder than tropical parks themselves (68% to 25% lost forest habitat)

Challenge: identify approach(es) for making E.O. data available for monitoring in North America—and share with the world

Global System of Protected Areas

Protected Areas

- > 100,000 in 188 countries
- > 18 million km2
- 11,5% of Earth's land surface
- Equals total area of China & Brazil; > Russia

But How Are We Doing?

- **McDonald's:**

30,000 restaurants in 119 countries

- **WalMart:**

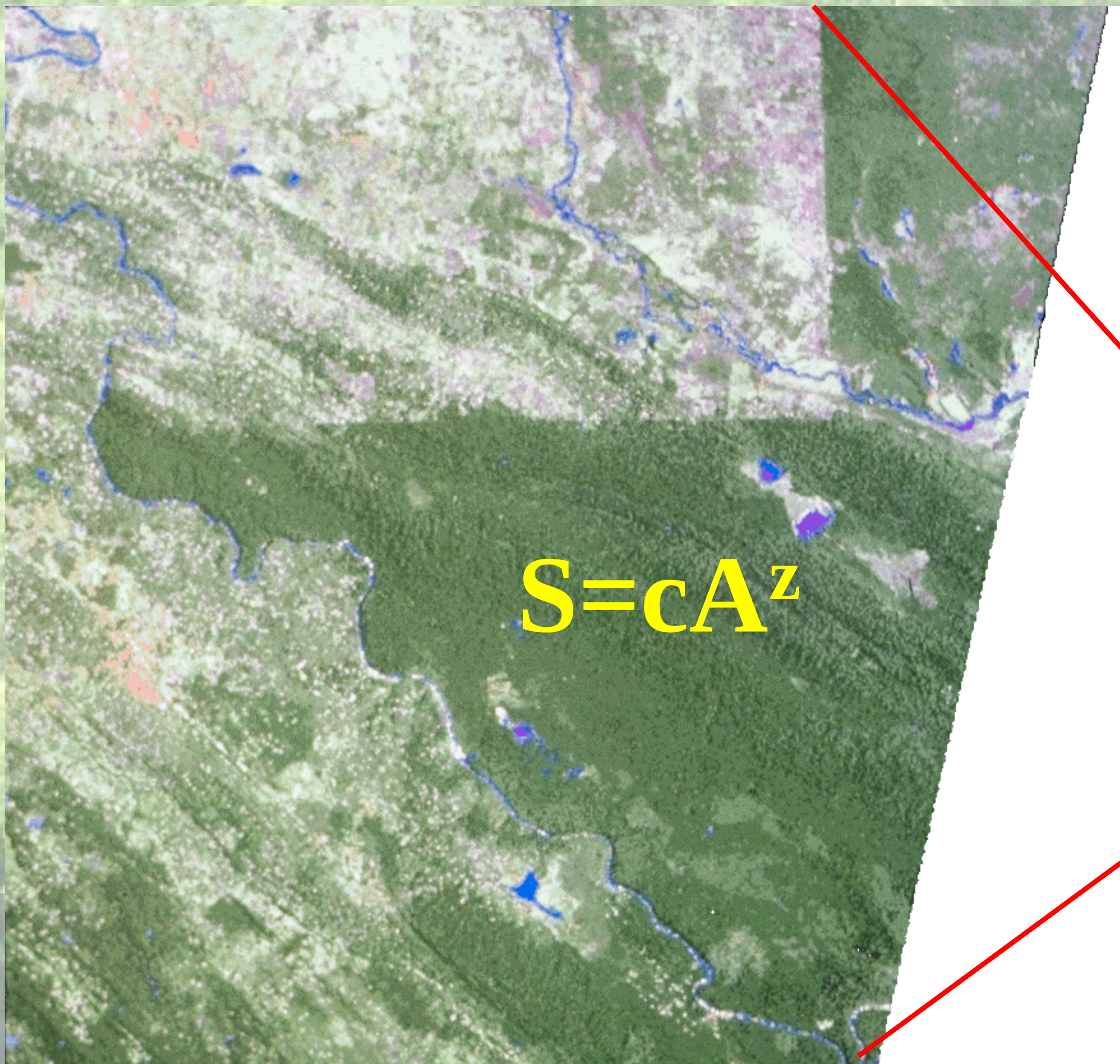
4,300 stores in 11 countries

- **How to track the health of PA's?**

(much of this slide courtesy of CI/CABS Gustavo Fonseca)

Size Matters

but so does climate, productivity, connectivity, cover, etc.



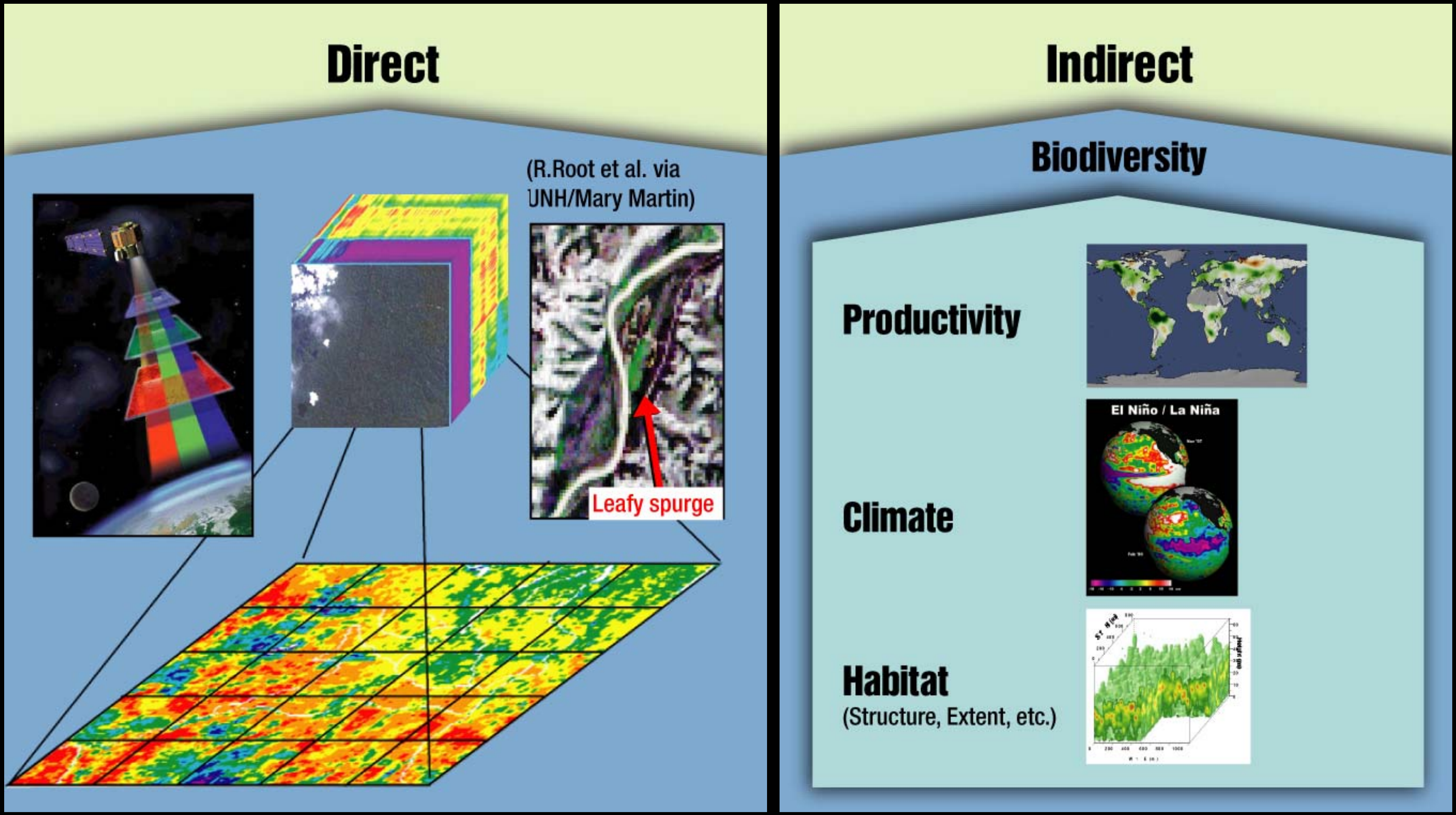
$$S=cA^z$$

Source: MSFC/Tom Sever & Dan Irwin

ARE ECOSYSTEMS GOOD REMOTE SENSING TARGETS?

- **Extent** (via land cover & coastal benthic environment characterization; moderate resolution only; need higher spatial/spectral resolutions)
- **Controlling Factors**
    - Temperature (ok for surface temperatures but coarse spatially)
    - Light (pretty well; PAR needs help)
    - Water (e.g., precipitation: working it; soil moisture: very coarse)
    - Nutrients (imaging spectrometers would help)
- **Characterization**
    - Structure → habitats (active sensors offer hope for terrestrial & marine; habitats, aka niches, help define biotic drivers like competition & predation)
    - Topography (slope/aspect/elevation; active sensors providing useful data)
    - Sea Surface Circulation (for planktonic distribution; need salinity)
- **Disturbances**
    - Land Use Change (moderate spatial scales; link sensors across scales for zoom capability via sensor webs)
    - Fire/Insect Outbreaks (satisfactory coarse resolutions; need more thermal IR data & higher spatial resolutions)
    - Floods/Droughts (floods: active sensors; drought stress: spectrometers)

REMOTE SENSING FOR BIODIVERSITY CONSERVATION
2 Approaches

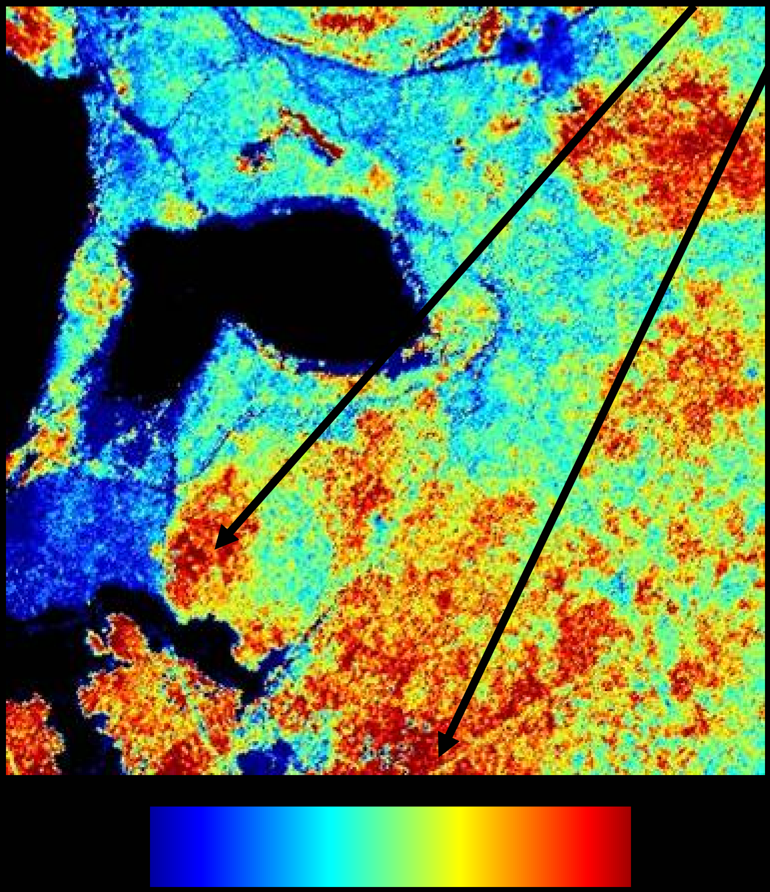


Direct Observations

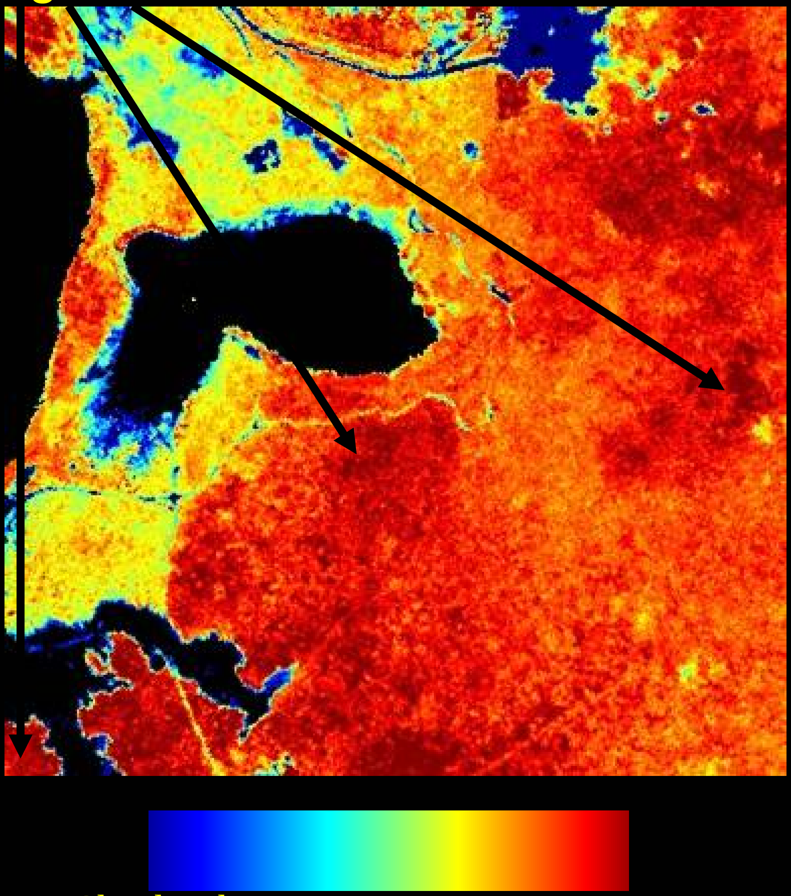
Identifying Plant Functional Groups Using Hyperspectral Sensors

Hawai’i Volcanoes National Park

Invasive Nitrogen-”fixer”

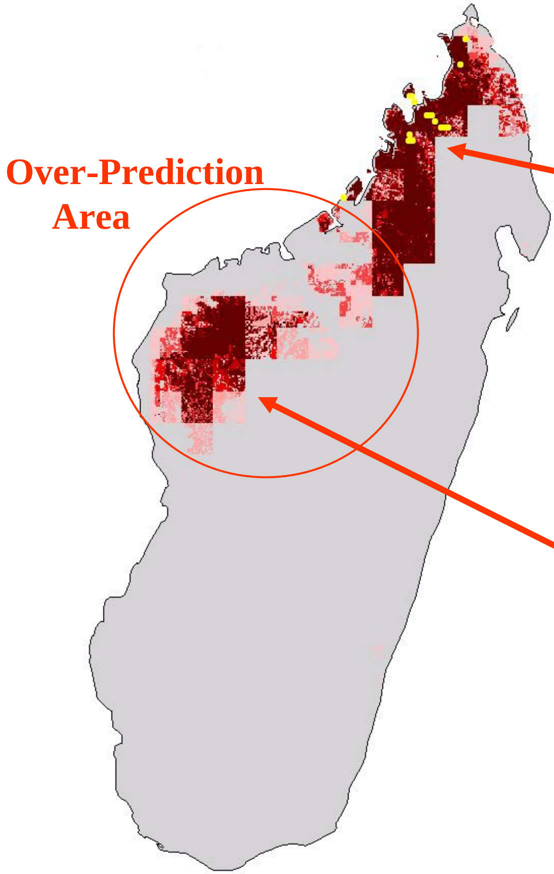


Canopy Water Content



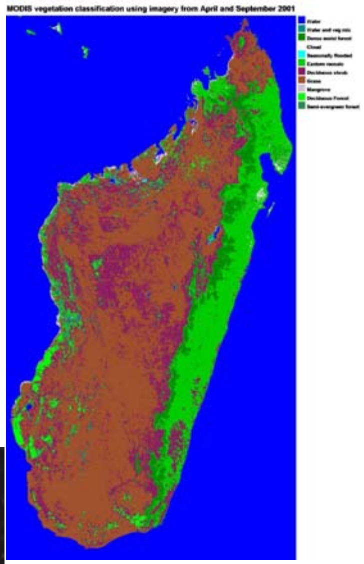
Leaf Nitrogen Concentration
(Courtesy Stanford/G. Asner)

Ecological Forecasting of Unknown Sister Species Bringing Together Satellite, Field, & Museum Data

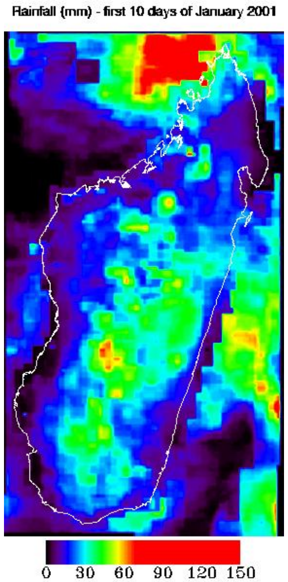


Brookesia stumpffi

Brookesia sp. nov.



MODIS Land Cover at 1km



NOAA Precipitation at 5 minutes resolution

Examples of Environmental Data Used

Modeled Distribution for *Brookesia stumpffi*

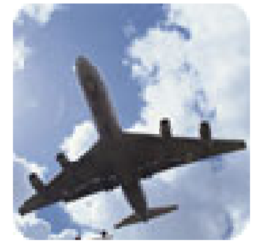
- Using Satellite imagery, other environmental layers, & collections data from the field & museums to run the GARP model→successfully predicted the distributions of 11 chameleon species in Madagascar
- Accuracies of 75 to 85%
- Areas of over-prediction from the model & subsequent field surveys → discovery of 7 new species
- These new species are local endemics, i.e.: found only within a limited area
- Profound implications for conservation & ecological forecasting

Source: AMNH/Chris Raxworthy

NASA Applied Sciences Programs

Agricultural Efficiency

Air Quality



Aviation

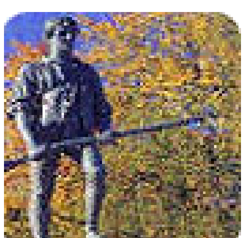
Carbon Management

Coastal Management

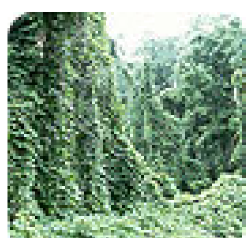
Disaster Management

Ecological Forecasting

Energy Management

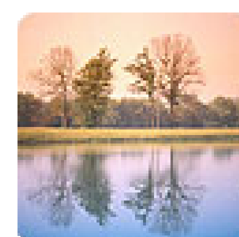


Homeland Security



Invasive Species

Public Health



Water Management

Ecological Forecasting

EARTH SYSTEM MODELS

•*Ecological Niche* (GARP)
•*Scalable spatio-temporal models* a la CSU's NREL
•*Regional Ocean Models & Empirical Atmospheric Models coupled with ecosystem trophic models*
•*Ecosystem* (ED, CASA)
•*Population & Habitat Viability Assessment* (VORTEX, RAMAS GIS)
•*Biogeography* (MAPSS, BIOME3, DOLY)
•*Biogeochemistry* (BIOME-BGC, CENTURY, TEM)

Predictions

•Species Distributions
•Ecosystem Fluxes
•Ecosystem Productivity
•Population Ecology
•Land Cover Change

Data

EARTH OBSERVATORIES

•*Land cover*: MODIS, AVHRR, Landsat, ASTER, ALI, Hyperion, IKONOS/QuickBird
•*Topography/Vegetation Structure*: SRTM, ASTER, IKONOS, LVIS, SLICER, Radars
•*Primary Productivity/Phenology*: AVHRR, SeaWiFS, MODIS, Landsat, ASTER, ALI, Hyperion, IKONOS, QuickBird, AVIRIS
•*Atmosphere/Climate*: AIRS/AMSU/HSB, TRMM (PR, LIS, TMI), AVHRR, MODIS, MISR, CERES, QuikScat
•*Ocean*: AVHRR, SeaWiFS, MODIS, TOPEX/Poseidon, JASON, AQUARIUS
•*Soils*: AMSR-E, AIRSAR *(Future Mission)*

•Land Cover/Land Use & Disturbances (e.g., fire)
•Species Composition
•Biomass/Productivity
•Phenology
•Vegetation Structure
•Elevation
•Surface Temperature
•SST, SSH, Circulation, & Salinity
•Atmospheric Temp.
•Soil Moisture
•Precipitation
•Winds

Observations

DECISION SUPPORT TOOLS

•SERVIR (Spanish acronym for Regional Visualization & Monitoring System)
- **•Monitor changes in land cover, weather, & fires to assist the sustainable management of the Mesoamerican Biological Corridor**

•Protected Area Management
- **•Agreement with National Park Service (NPS) 1/05**
- **•Support for NPS Inventory & Monitoring activities**

•Impact of ENSO & PDO Events on Fisheries
- **•Combine physical ocean & ecosystem trophic-level models to predict how climatological changes driven by ENSO & PDO events will affect regional fisheries**

If-Then Scenarios for Ecosystem Responses To Change

VALUE & BENEFITS

•First-ever effort to manage a global hotspot of biodiversity, i.e. Mesoamerica, at a regional scale through the coordination of the activities of 7 countries – a model for other regions

•Predict the impacts of changing land-use patterns & climate on the ecosystem services that support all human enterprises

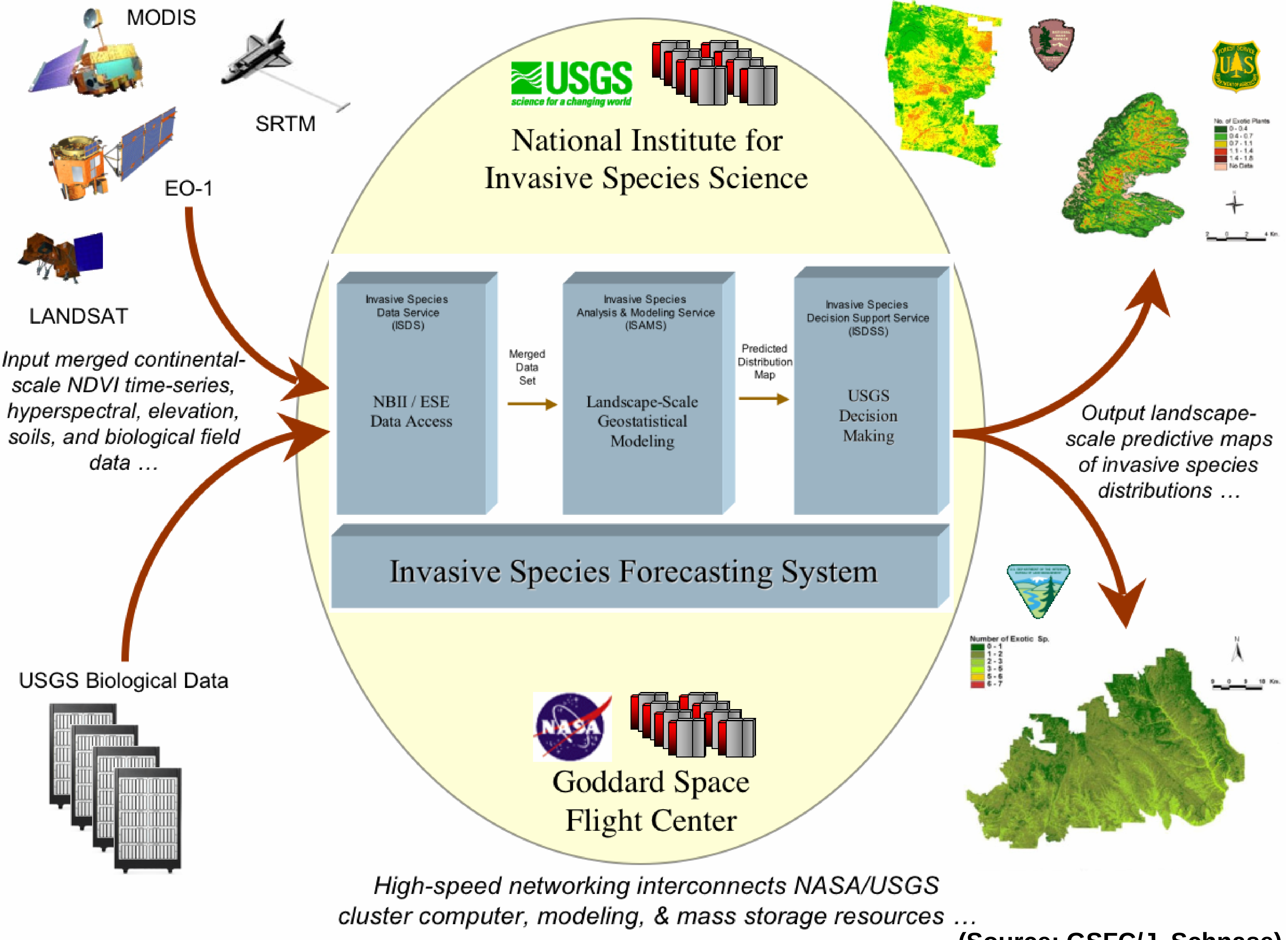
•Develop ecological forecasts with reliable assessments of error

Who's Here?

	Park Ecologists	Remote Sensing Experts
Canada		
U.S.		

Some Keys to Success

- Listen to park folks
- Don’t oversell
- Address continuity of data
- Address accuracy of data
- Explore models to translate data
- Think like a ranger



(Source: GSFC/J. Schnase)